



# **Commercial Crew Program Status**

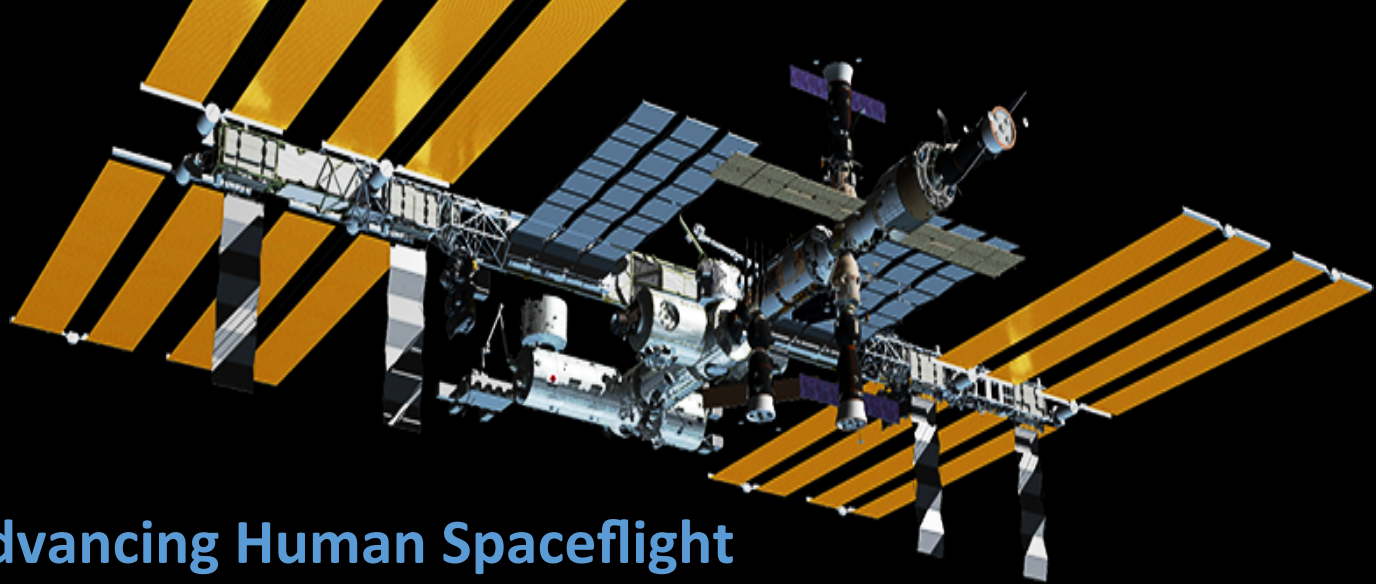
**Phil McAlister  
NASA Headquarters  
March 2, 2016**



# Agenda



- Commercial Crew Program (CCP) Highlights
- Milestone Status
- Space Act Agreement Summary
- CCP Top Program Risks
- Boeing Summary
- SpaceX Summary
- Special Topic: CCP Certification
- Summary



## Advancing Human Spaceflight

The vision of commercial human spaceflight to low-Earth orbit is a robust, vibrant enterprise with many providers and a wide range of private and public users.

A successful human space transportation system will strengthen the International Space Station Program, allow NASA to focus on deep-space exploration, potentially reduce the cost of human access to space and significantly contribute to the national economy.

### *CCP Public Purpose*

Support the development of non-NASA markets for commercial human transportation services to and from low-Earth orbit.

### *CCP NASA Purpose*

Safe transport of NASA and NASA-sponsored astronauts to and from the station.



# Highlights

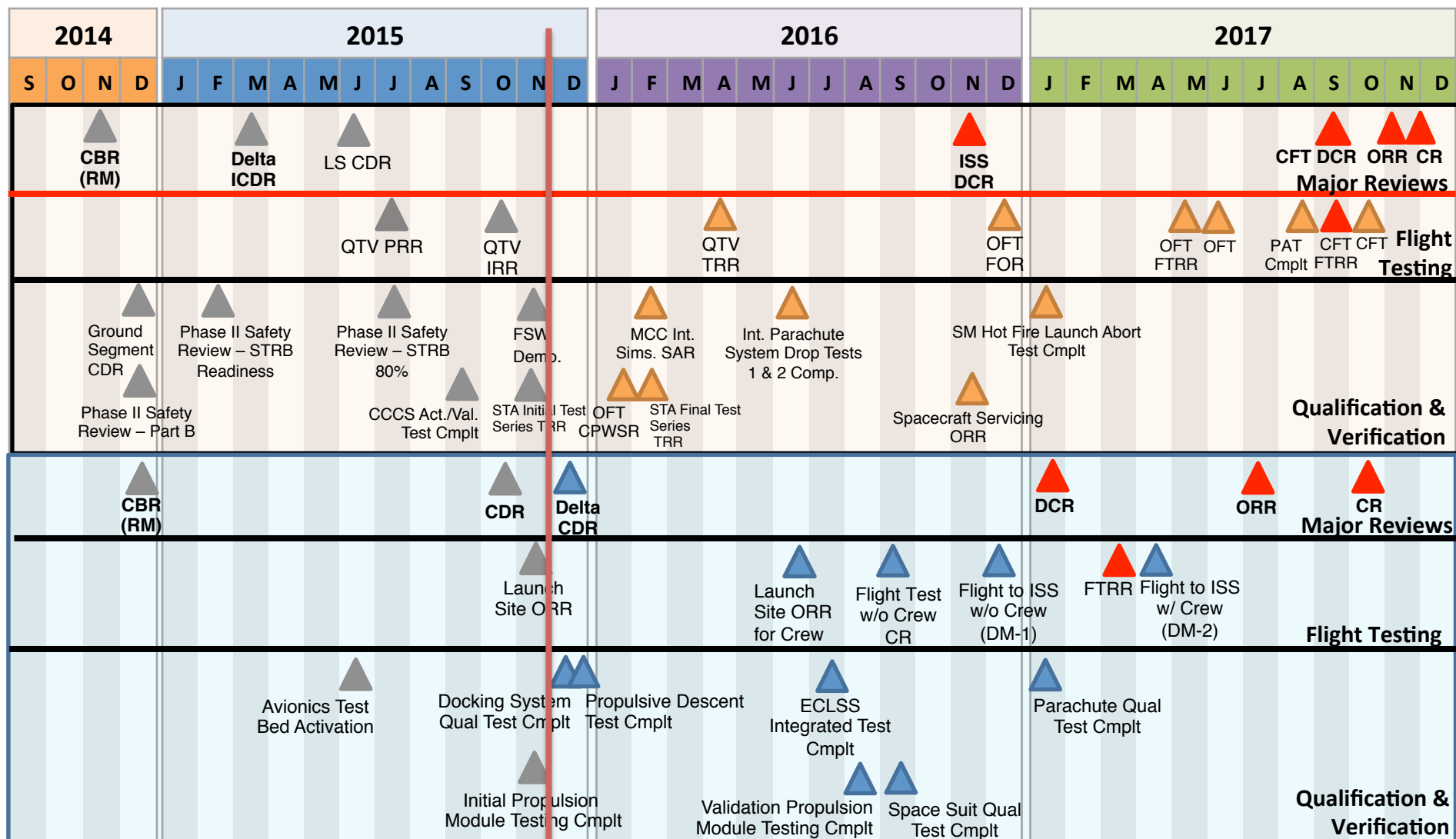


**CCP has made significant progress over the last quarter, notably:**

- **Continue to burn down key products with the providers**
  - Over 60% of the Alternate Standards have been dispositioned
  - Over 40% of the Variances have been dispositioned
- **Updated NASA Certification Plan and baselined the Certification of Flight Readiness (CoFR) Plan**
- **Awarded Post Certification Missions (PCMs)**
  - For SpaceX:
    - PCM-1 awarded November 2015; Completed one milestone to date
    - PCM-2 award expected in August 2016
  - For Boeing:
    - PCM-1 awarded May 2015; Completed three milestones to date
    - PCM-2 awarded in December 2015; Completed one milestone to date



# CCTCap Combined Milestone Summary



CCTCap CMS-Official November 30, 2015

- ▲ Required Milestone (RM)
- ▲ Boeing Milestone
- ▲ SpaceX Milestone.



# SAA Combined Milestone Summary



## SAA Combined Milestone Summary (Official)

SAA CMS - Official February 12, 2016 FY16Q1 POC: Emily Weiland 321-867-4052  
Data Source: CCP SAA Milestone 12/08/15

FY15												FY16												FY17					
Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
<b>Blue Origin - CCDev2</b>																													
4/2 ▲ Dev2 Semi Annual Review																													
MS# 3.9 - Flight Demo of Subscale Propellant Tank Assy ▲ 3/1																													
MS# 3.8 - Flight Demonstration of BE-3 Engine ▲ 3/1																													
3/1 ▲ MS#2.7-Pusher Escape In-Flight Escape Demo Data Review																													
3/1 ▲ Dev2 Semi Annual Review																													
<b>SNC - CCIcap</b>																													
11/24 ▲ MS# 15a-Reaction Control System Testing-Incremental Test #1																													
1/29 ▲ Quarterly Review																													
4/29 ▲ Quarterly Review																													
7/29 ▲ Quarterly Review																													
▲ Quarterly Review																													
1/29 ▲ Quarterly Review																													
3/1 ▲ MS# 41-Design Analysis Cycle-6 (DAC-6) Closeout Review																													
3/1 ▲ MS# 4b - Eng Test Article Flight Testing #2/ Review																													
<b>SpaceX - CCIcap</b>																													
11/24 ▲ MS# 12a - Dragon Primary Structural Qual																													
12/22 ▲ MS# 13d - Interim Progress Crew Vehicle Delta CDR																													
1/22 ▲ Quarterly Review																													
5/29 ▲ MS# 11 - Pad Abort Test																													
5/14 ▲ Quarterly Review																													
8/14 ▲ Quarterly Review																													
11/16 ▲ Quarterly Review																													
12/15 ▲ MS# 13e - Delta Crew Vehicle Critical Design Review																													
5/1 ▲ MS#12b-Dragon Primary Structure Qual - Hatch Open Test																													
MS# 14 - In-Flight Abort Test ▲ 3/1																													



# CCP Top Programmatic Risks

## 1/26/16



### Program Control & Integration (PC&I)

- Requirement Changes (PCI-2015-3)
- Additional Cost for IV&V (PCI-2015-4)
- Budget Uncertainty (PCI-2015-2)
- Maintaining knowledge and continuity with a skilled and stable Civil Service workforce (PCI-2014-2)

### Systems Engineering & Integration (SE&I)

- Ability to Close the Loss of Crew Gap (SEI-2015-1)

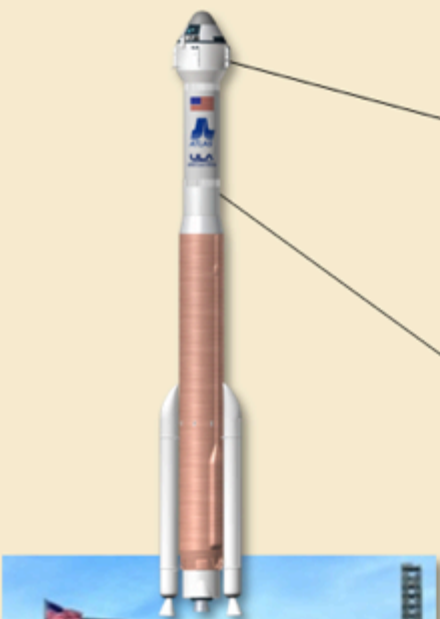
### Ground & Mission Operations (G&MO)

- DoD Search & Rescue Training Schedule (GMO-2015-4)
- Search and Rescue Posture (GMO-2015-3)

Likelihood	5	GMO-2015-3		PCI-2015-3 PCI-2015-4	
	4				
	3			GMO-2015-4	SEI-2015-1
	2				PCI-2015-2
	1		PCI-2014-2		
		1	2	3	4
Consequence					



# Boeing Architecture Description



## Spacecraft Segment

Simplicity of design with high maturity through use of existing technologies within Boeing and from our key suppliers such as Aerojet Rocketdyne and General Dynamics

- Crew Module
- Service Module
- Flight Software

## Launch Segment

Mature design through use of heritage design, production, and operations from our key supplier ULA

- Launch Vehicle
- Launch Pad
- Launch Control Complex
- Pad Test and Checkout
- Spacecraft / LV Integration
- Emergency Detection System

## Ground and Operations Segment

Mature design and processes through use of proven Boeing production techniques

- Cargo Integration
- Assembly, Integration and Test Facility
- Landing and Recovery
- Landing Site Facilities
- Network Services

Mature mission operations through use of heritage mission support from our key supplier JSC/Flight Operations Directorate (FOD)

- Crew Training
- Mission Control Center
- Mission Planning
- Training Systems
- Mission Operations





# Boeing Accomplishments



Significant progress made over last quarter:

- Crew Access Tower main column complete
- Crew Access Arm and White Room testing in work
- Passive Thermal and ECLSS CDRs completed
- Solar Array Delta CDR completed
- Structural Test Article production progressing to support testing
- Several component-level development and qualification tests completed
- New flight software released
- Emergency detection system risk reduction test completed
- Service Module hot fire test site in work
- Hardware delivery ramping up
- Alternate standards and variances approved by NASA
- Astronaut and flight crew teams performing mission simulations



Crew Access Arm and  
White Room Testing



ECLSS CDR Passed



Crew Simulator Training  
Ongoing



Structural Test Article  
Production Progressing



Air Bags Qualification Tested for Emergency Water Landings

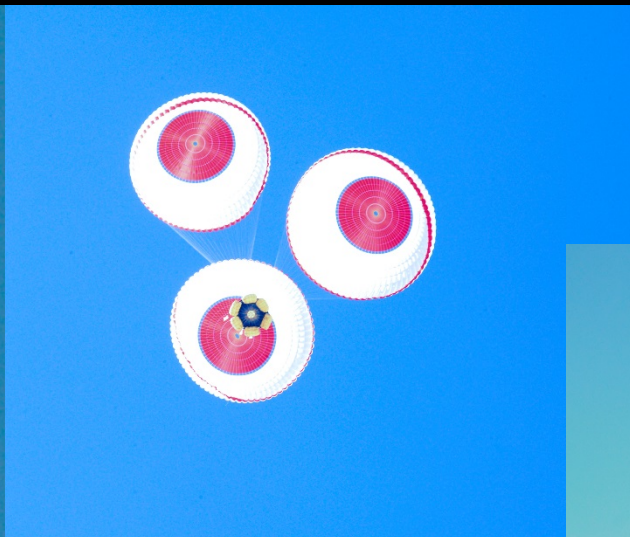
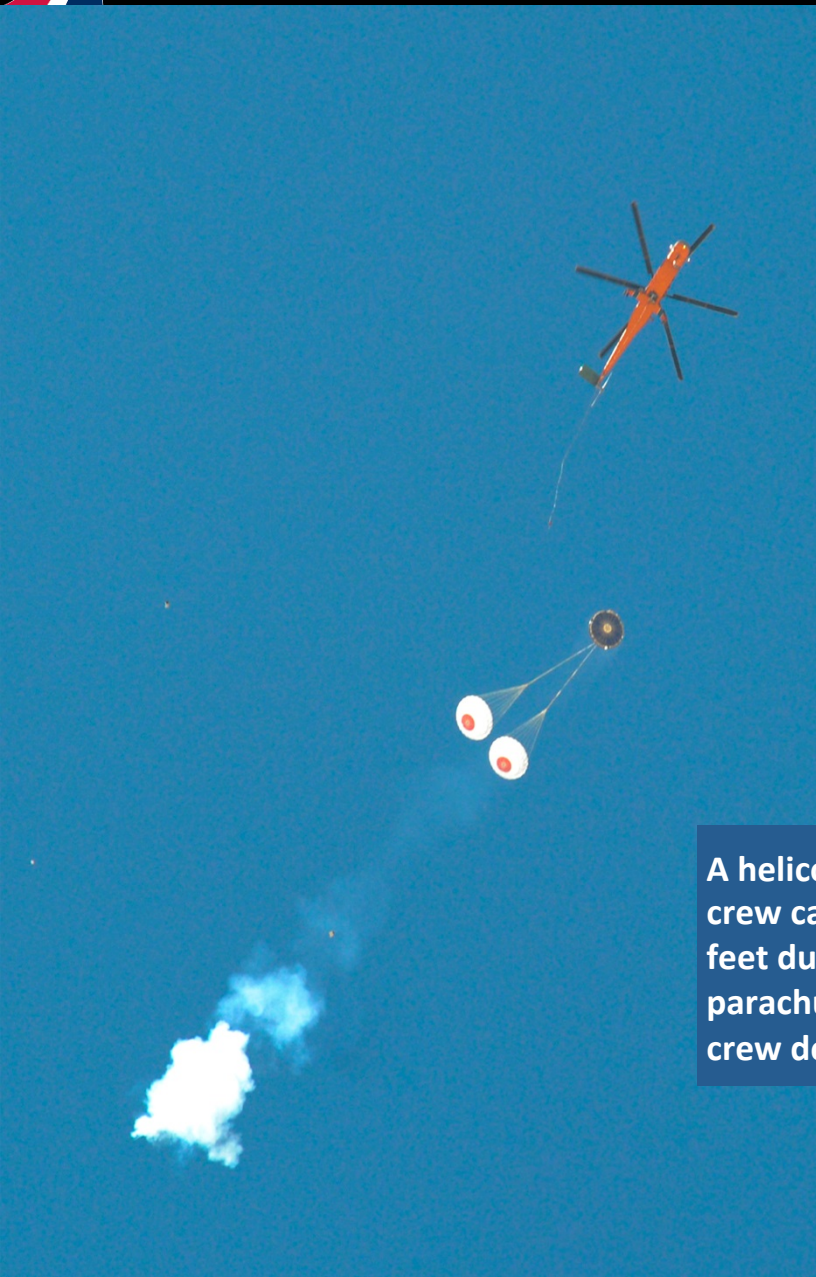


Crew Access Tower Main  
Column Complete





# 2 May 2012 Helicopter Drop Testing



The main parachutes deploy

A helicopter drops Boeing's CST-100 crew capsule from about 10,000 feet during the company's second parachute drop test for commercial crew development activities.



Boeing's CST-100 crew capsule floats to a landing above the Delmar Dry Lake Bed near Alamo, Nev.,

Image credits: Boeing



# SpaceX System Description



- **Spacecraft Segment (Dragon)**
  - Crew Dragon
  - Trunk
  - Launch Abort System (internally integrated in Dragon)
- **Launch Segment (Falcon 9)**
  - Full thrust Merlin engines
  - Densified propellants (chilled LOX & RP-1)
  - Common First stage w/Falcon Heavy design
  - Autonomous Flight Termination System
  - Landing legs (stowed in ascent)
  - Stage separation system
- **Ground and Operation Segment**
  - Launch Operations System
    - Launch Pad (LC39A), Launch Pad facility, Ground SW, & Launch Control Center
  - Mission Operation System
    - MCC (Hawthorne) Crew Ops, Training & Sim, & Recovery



Falcon 9



Crew Dragon Vehicle



Launch Control  
Cape Canaveral, FL



Mission Control  
Hawthorne, CA



LC-39A  
Kennedy Space Center, FL





# SpaceX Accomplishments



Parachute Mass simulator test



Propulsive landing test

## Significant progress made over the last quarter:

- **Completed two Critical Design Reviews**
  - Dragon, F9, ground systems, and operations
  - SpaceX in the process of addressing all NASA comments to satisfaction
- **Propulsion System Testing**
  - Began Initial propulsive landing tests (Pad abort vehicle)
  - Propulsion system testing (SuperDraco Module)
- **Activated 39A launch site**
- **Good progress on space suit and helmet design**
- **Crew Module seats being modified to maximize crew safety**
- **Flew upgraded F9 that will carry crew**
- **Completed first 4-parachute test**
- **Qualification and production on key components**
  - Dragon vehicle structures are in production
  - Conducted Qualification testing of several F9 Systems and development testing of stage separation system to human standards
  - Completed Docking System Qualification
- **Approved alternate standards**
  - Software alternate standard approved
  - Avionics environmental testing alternate standard approved



# SpaceX Crew Dragon Parachute Drop Test



January 27, 2016. Parachute drop test for SpaceX crew Dragon involving four red-and-white parachutes unfurled from a mass simulator high above the desert near Coolidge, Arizona.



# NASA CCP Certification



- **CCP Certification/CoFR strives to achieve a balance of insight/oversight appropriate for shared government & industry accountability in establishing a safe, reliable, and cost-effective CTS**
  - The **Industry Partner** is responsible for the design, development, test and evaluation; culminating in their certification assertion of its CTS to transport crew to and from the ISS.
  - **NASA CCP** is accountable for **ensuring compliance** to CCP's human spaceflight requirements thru **evaluation and approval** of the Contractor's compliance evidence and execution of **NASA's insight** into the Contractor's solution in accordance with a risk based insight approach implemented under a shared assurance model.



# Government / Industry Accountability



## Allocation of Responsibilities

	Activity	NASA	Industry	
Design Cert	Establish Requirements	<ul style="list-style-type: none"><li>Flow down and Tailor Agency Rqmts (Mission Rqmts, HRR, Standards)</li><li>Disposition Rqmts Variances</li></ul>	<ul style="list-style-type: none"><li>Flow down of CCP Requirements and Tailoring;</li><li>Evaluate Rqmts Achievability</li></ul>	
	Manage Development Risk	<ul style="list-style-type: none"><li>Development Oversight</li><li>Elevate Design and Development Risks from Insight</li></ul>	<ul style="list-style-type: none"><li>Produce Mgmt Plans</li><li>Perform Risk Reduction Planning</li></ul>	
	Establish Cert Baseline	<ul style="list-style-type: none"><li>IV&amp;V</li><li>Accept Cert Compliance</li><li>Support Joint Test Planning</li><li>Accept Residual Risk</li></ul>	<ul style="list-style-type: none"><li>Submit Cert Data Packages</li><li>Perform System Validation</li><li>Quantify Residual Risk (PSA, Reliability)</li></ul>	◀ CTS Certified
Flight Cert	Validate Baseline Cert	<ul style="list-style-type: none"><li>Quality Assurance Audits</li><li>Accept Problem Resolutions</li></ul>	<ul style="list-style-type: none"><li>Accept Hardware</li><li>Problem Identification, Resolution, Corrective Actions</li></ul>	
	Assess Mission Readiness	<ul style="list-style-type: none"><li>Accept Flight Certification and Residual Risk</li></ul>	<ul style="list-style-type: none"><li>Compliance Evidence of Hardware/Team Readiness</li></ul>	◀ Flight Readiness Certification

***By design, the CCP model allocates greater accountability to industry.***



# Summary



- **Boeing and SpaceX are advancing their design concepts**
  - Actively building and testing hardware to inform design
  - Engaging in meaningful insight with NASA
  - Addressing important design challenges
- **CCP has robust and efficient processes for certification including addressing waivers and deviations**
- **In preparation for flight, there is significant work ahead**

